- Volcanoes
- **Chapter 5**

Rigid Earth to Plate Tectonics

- **Learning Objectives**
- **Know the different types of volcanoes and their associated features**
- **Understand the relationship of the volcanoes to plate tectonics**
- **Know what geographic regions are at risk from volcanoes**
- **Know the effects of volcanoes and how they are linked to other natural hazards**
- **Recognize the potential benefits of volcanic eruptions**
- **Understand how we can minimize the volcanic hazard**
- **Know what the adjustments we can make to avoid death and damage from volcanoes**

Introduction to Volcanoes

- **General term that refers to all phenomena connected with the origin and movement of molten rock**
  - **Two categories–Surface and Plutonic Activities** (below the surface of the crust)
  - **Extrusive volcanism (explosive above ground)**
  - **Intrusive volcanism (shallow none explosive)**
  - **Plutonic (intrusive, very deep under ground)**

Magma

- **Magma**
  - **Molten mineral material below the surface** –
  - **Lava when extruded to the surface**.
  - **Explosive material is pyroclastic material**
  - **Distribution**—Most found in the Ring of Fire or at subduction zones
- **Magma Chemistry and style of eruptions**
- **Felsic Magma** – Rhyolite and Granite
- Explosive eruptions
  - **Mafic Magma** – Basalt and Gabbro
- Slow moving, non-explosive

How Magma Forms

- Decompression melting – when overlying pressure is exerted on hot rock within the asthenosphere is decreased.
  - Happens at Hot Spots and Divergent boundaries
- Addition of volatiles lowers the melting temperature of rocks by helping to break chemical bonds within silicate minerals
- Volatiles are chemical compounds, such as such as water or carbon dioxide that evaporate and exist in a gaseous state at the earth's surface

- Addition of heat to rocks will induce melting if the temperature of the rocks exceeds the melting temperature of silicate rocks at that depth

Properties of Magma

- Magma is made up of melted silicate rocks
- Basaltic, Andesitic, and Rhyolitic
- Magma is less dense than surrounding rock therefore it rises buoyantly towards the surface
- As it moves towards the surface and melting takes place, chemical processes happen and magma becomes more felsic
- Viscosity is the resistance to flow due to greater amounts of silica in the magma
- The viscosity of the magma influences the type of volcano
- Volatile Content of the volcano is connected to a high concentration of dissolved volatiles within the magma

Types of Volcanoes

- **Shield**
- Broad, gentle slope
- Largest in the world
- Layers of lava flows
- Basaltic magma, quiet eruptions
- Common in islands, Hawaii and Iceland
- **Composite**
- Large, steep, symmetrical
- Beautiful cone shape
- Layers of lava, proclastic
- Magma andesitic, both explosive and quiet eruptions
- Mt. Fuju, Mt. St. Helen, Mt. Rainier
- **Lave Dome**
- Small, less than 2000 ft. high, irregular shape
- Solidified thick viscous lava
- Magma high in silica, often rhyolite
- **Cinder Cone**
- Small Steep-sided.
- Loose proclastic material
- Magma varies from basaltic to proclastic

Parts of Volcanoes

- Volcanoes are more than complex systems in a mountain that spews lava
- These systems include:
- Craters, calderas, volcanic vents, geysers, and hot springs

- **Craters** – formed at the topes of volcanoes during the explosion
- **Volcanic vent** -- an opening through with lava and pyroclastic erupts
- **Hot Springs or geysers** – where groundwater comes into contact with hot rock
- **Caldera** --a crater produced from a collapsed volcano

Types of Volcanoes
Igneous Features

- **Igneous intrusions – when the magma solidifies below the surface producing a igneous intrusion**
- **Dikes – a vertical or nearly vertical sheet of magma thrust upward into preexisting rock**
- **Sills– a long, thin intrusive body with its orientation determined by the structure of the preexisting rocks.**
- **Veins – least prominent- thin veins of igneous rock that are pushed up through small fractures of preexisting rocks**.
- **Batholiths -- a subterranean igneous body of indefinite depth and enormous in size. Often the core of mountain ranges.**
- **Stocks – Similar to the batholiths but much smaller. Often an offshoot of batholiths.**
- **Laccoliths– produces by slow-flowing viscous magma is forced between horizontal layers of preexisting rock.**

Mid-ocean Ridges and Continental Rifts Volcanoes

- Mid-ocean ridges and continental rifts
- Produces basaltic magma
- Produces shield volcanoes
- Iceland an example

Subduction Zone Volcanoes

- Subduction Zones
- Found around the Pacific Rim
- Volcanoes commonly andesitic
- Magma combination of basalt and silica
- Japan and volcanoes in Oregon, Washington and Alaska are examples

Convergent Boundaries

- Convergent Boundaries– where plates collide destructive boundaries
- Most massive and spectacular of earthly landforms
- Mountains & volcanoes
- Deep ocean trenches

Hot Spots

- **Hot Spots**
- Spots of volcanic activity caused by a thin Earth's crust allowing the magma to move to the surface found in the ocean
- These are called **Hot Spots**
- **Hawaii** is an example
- As the plate moves across the Hot Spot, a **hot spot trail is left, such as the Hawaiian Islands or Midway**.

Mantle Plums

- **Mantle Plumes**
- Spots of volcanic activity caused by a thin Earth's crust allowing the magma to move to the surface
- These are called **Mantle Plumes**
- Yellowstone sits over a mantle plume
- As the North American plate moves across this mantle plum**,** Yellowstone will move across the country
- **Mantle plumes help to explain volcanic activity in the middle of plates and help to distinguish the direction of the plate's movement**.

Geographic Regions at Risk from Volcanoes

- Earthquakes, volcanoes are related to tectonics and most occur around the Ring of Fire
- Hot spots or riffs found in the Pacific Ocean or at mid-ocean ridges
- Areas along the Pacific Coast, in Yellowstone and in isolated areas of the Southwest are at risk

Pacific Ring of Fire

- **Ring of active volcanoes surrounding the Pacific Ocean**
- **Found primarily along the subduction zones of the Pacific Basin plate boundaries**
- **Some segments along the transform and divergent plate boundaries**

Volcanic Hazards

- **Lava flows**
- Rarely cause loss of life, but cause lots of damage
- **Proclastic flows**
- Collapse of the lava dome or explosive eruption causes high speed avalanche of searing hot gases, ash, and rock fragments
- **Volcanic Ash**
- Covers vegetation, contaminates surface water, damages buildings as ash piles on roofs, creates health hazards, and can cause flame outs in airplane engines
- **Volcanic Gases**
- Emissions of noxious gases such as carbon dioxide, sulfur dioxide, hydrogen sulfide, and fluorine
- **Eruption Column and Clouds**
- Changes the air quality and weather
- **Volcanic Mudflows (Lahars)**
- A loose mantle of ash and proclastic flow on the sides of a volcano slides during a heavy rain storm.

Linkages between Volcanoes and other Natural Hazards

- Volcanoes are linked to their physical environment as well as to several other natural hazards
- Fires
- Earthquakes
- Landslides
- A change in global climates

Natural Service Function of Volcanoes

- Volcanic Activity Serve in Natural Functions by
- **Volcanic Soils**
- Provides excellent growth medium for vegetation
- **Geothermal Power**
- Used to create power for nearby urban areas
- **Mineral Resources**
- Host and source for mineral resources
- **Recreation**
- Creates health spas and hot spots
- **Creation of New Land**
- Responsible for new land during the eruption

Human Interaction with Volcanoes

- Unlike earthquakes, volcanoes do not lend themselves to human tinkering, little can be done to stop them
- Minimizing the Volcanic Hazards
- Forecasting – Unable to forecast but certain information can be obtained that can help
- Monitoring seismic activity
- Monitoring thermal, magnetic, and hydrologic conditions
- Monitoring the land surface to detect tilting or swelling of the volcano
- Monitoring volcanic gas emissions
- Studying the geologic history of a particular volcano or volcanic center

Minimizing the Volcanic Hazards

- Monitoring **seismic activity**
- Small earthquakes around the area of a volcano
- Monitoring **thermal, magnetic, and hydrologic conditions**
- Magma accumulation can heat rock or water, change magnetic stimulus or change water temperature
- Monitoring the **land surface** to detect tilting or swelling of the volcano
- The change in the land surface around a volcano can indicate change in the volcano
- Monitoring volcanic **gas emissions**
- A volcano getting ready to erupt can have a change in gas emissions
- Studying the **geologic history** of a particular volcano or volcanic center
- Understanding the geologic history of the volcano can help in knowing if it is going to erupt

Volcanic Alert or Warning

- When should the public be alerted to the emanate danger of a volcanic eruption
- Using a system of ground-based levels and aviation-based color code levels, the public can be alerted to a volcanic eruption

- Developed by USGS, used by 5 volcanic observatories
- Each component has four levels for monitoring
- Usually the alerts for the volcanoes and eruptions will be the save for both levels (ground and aviation)
- But for some the ground alert maybe more than the aviation or reversed, depending the kind of volcano

Perception of and Adjustment to the Volcanic Hazard

- Information concerning how people perceive a volcanic hazard is limited
- People live near volcanoes for a variety of reasons
- They were born there and in the case of some islands, all land is volcanic
- The land is fertile and good for farming
- People are optimistic and believe an eruption is unlikely
- They cannot choose where they live, they may be limited by economics
- The best way to limit concern about living near a volcano would be to better understand the what needs to be done in a **volcanic crisis**

Perception of and Adjustment to the Volcanic Hazard

- **Adjustments to Volcanic Hazards**
- Major adjustment of understand evacuation
- People need to understand the hazards and when told to evacuate
- Some places are offering rewards to relocate
- **Attempts to control lava flows**
- There have been some attempts to regulate the flow of lava
- One way is called **hydraulic chilling** where the flow of lava is controlled
- For this to happen 3 things have to be available
- Slow movement of lava
- Available transportation and roads to move the machinery on
- Water is ready available